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COMMUNITY-SOURCING IN VIRTUAL SOCIETIES

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Abstract. The paper studies the approaches to development of goods with active participation of virtual community members. The concept of community-sourcing is presented as an alternative to the open source model and crowdsourcing. On that foundation a conceptual model of resource management system that use some current good practices of the IT industry is proposed. Results obtained in a virtual community implementing the model are presented as a validation attempt.

1. Introduction. The concept of virtual community was described in the late 1980s [1] and consequently received a significant impulse from technologies like the Internet, World Wide Web, discussion forums, computer supported social networks, among many others. The evolution of technology and research in the field resulted in quite a few attempts to define the term "virtual community" over the last 30 years; there are several research papers in both sociology and computer science focused specifically on the terminology. This research uses Leimester's

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definition: "A virtual community consists of people who interact together socially on a technical platform" [2].

The combination of decrease in requirements for technical skills and infrastructure costs needed to participate in or to found and develop a virtual community led to a sharp rise of the number of communities and the number of participants—from an estimate of about 90 million US users at the dawn of the 21th century [3] to the staggering 1.7 billion active users reported by Facebook only in 2016 [4]. The focus of the research in the field and software engineering effort in the last two decades is moving from solving communication and technical problems towards interdisciplinary problems like leadership, user motivation and engagement approaches.

This paper studies the creative potential of the virtual community environment and the opportunity that it presents for development of goods with active participation of community members. The focus is especially on those goods whose manufacturing requires complex skill and resource sets and production and development processes.

2. Research problem and current state of studies. The social and economic importance of the virtual community phenomenon was instantly recognized and a significant research effort was put on the field beginning with the 1990s. Grannoveter's Weak Ties Theory [5] is one of the foundations that is frequently used to explain the enormous information [6] and innovative potential [7] of the virtual community and the emergence and rise of computer supported social networks [8] like Facebook. The Social Capital Theory [9], [10] suggests that the relations between individuals in the community is a form of capital. Lin [11] argues that the social capital can be used for improving the well-being of both the individual and the society. That thesis is also supported by Nahapiet and Ghoshal [12], who develop a three dimensional model of the social capital that is widely used today.

Numerous empirical studies demonstrate motivation of the virtual community members for contribution with content and knowledge sharing. Connoly et al. [13] and later Ardichvili et al. [14] studied motivational factors and participation barriers to the users in corporate virtual communities of practice and concluded that some groups of users are not just eager to contribute but even feel obligated to do so for the community; Koh et al. [15] explicitly stressed the importance of user contribution for the success of the virtual community; Ardichvili et al. and Rojo and Ragsdale [16] also noted the importance of the organization and leadership of the community for development of an environment that will benefit the users who contribute. In a review of the results of last the 15 years of research, Tedjamulia et al. [17] noted that community managers need more comprehensive controlling, motivating and user effort management mechanisms.

This short literature review demonstrates that the researchers are well aware of the creative potential of the virtual community. However, a significant gap exists between the efforts to identify, explain and stimulate contribution motivation factors in the virtual community and the efforts to provide a mechanism to effectively employ the resources of a person or team already motivated and willing to contribute. This constitutes a research problem that still persists. For the last 30 years software engineers and virtual community leaders have had the general lead in the solving effort. Various solutions can be extracted either through feature analysis of major software products for virtual communities or business analysis of successful virtual communities and underlying business models.

The open source model is one such mechanism that uses the contribution of the virtual community members in product development [18]. It allows access to the components of the product to anyone with the purpose to improve the quality of its features or even to modify and add new features. The team that develops a particular product is free to organize itself and structure its work in its own will [19], and there is no specified mechanism in the model that allows provisioning with resources outside of the team—devising such a mechanism is a prerogative of the leadership of a particular team. Since the original intent of the model was to enable development of software products by professional software engineers and enthusiasts, a solution was found with emergence of various profit and non-profit organizations that provide support for open source software projects [20]. Theoretically, any good that requires a complex skill set, has specific infrastructure requirements, has mixed virtual and physical nature or is entirely physical may be developed using all or some of the principles of open source. One of the most important factors for the success of an open source project that are frequently mentioned by the researchers and participants is the development of a strong community.

Crowdsourcing was introduced by Howe in 2006 [21] as a further development of the outsourcing concept—"... crowdsourcing represents the act of a company or institution taking a function once performed by employees and outsourcing it to an undefined (and generally large) network of people in the form of an open call." Prpić et al. [22] proposed the term "crowd capital" to describe the resources that are acquired by organizations through crowdsourcing. Although there are enough clues that crowdsourcing is an effective production mechanism that works with large groups of people, there is a fundamental problem that contradicts with the concept of community—by definition the crowdsourcing model works with an anonymous crowd. The crowd is treated and managed as a "single construct: a general collection of people that can be targeted by firms" [22]. Thus, an eventual virtual community is either a byproduct or a proxy for gathering the crowd. This raises an issue with several well-known factors that motivate contribution in the virtual community like self-esteem, enjoyment of social interaction, building a position in society [23]. The potential for problem solving of the distributed online model of crowdsourcing was reviewed by Brabham [24] who studied several samples of the crowd contribution in development of solutions to various business challenges. He compared crowdsourcing and open source models and argued over the differences between them. Brabham's study presented a slightly different point of view over crowdsourcing in which some typical community characteristics were put on the crowd.

The general objective of the research presented in this paper is to outline an alternative approach that facilitates the participation of virtual community members in the development of goods. The research effort is motivated by the idea of finding a middle ground between a less structured and liberal open source model and a firmly structured but more restrictive crowdsourcing model. In some sense it is a continuation of Brabham's studies and is inspired by it.

A systematic community-sourcing approach based on four assumptions is proposed. On that foundation a conceptual model of resource management system that uses some current good practices of the IT industry is proposed. Results obtained in a virtual community that implements the model are presented as validation clues.

3. Community-sourcing approach in virtual communities. A basic suggestion in the development of the approach is that the virtual community can be a sustainable source of resources that may be used in the development of goods with complex features. However, a prerequisite to facilitate that is to create a favorable environment. The team that governs a community can and must put significant effort into organizing it if they want to use its resources in complex endeavors—as the open source model demonstrates. The resources of the anonymous crowd may be used with a structured management framework and defined tasks and awards system as crowdsourcing demonstrates.

In order to explain the community-sourcing approach an economy perspective is used. The community is presented as a production system that processes resources in order to produce goods. The approach is based on two couples of assumptions that are explained in this section.

The first assumption is that two subclasses of resources, determined by the relevant source, exist in the virtual community. The first type are those that are owned and delivered by the community governors; the second type are the resources that are owned and delivered by community members. The subdivision would allow different management approaches to be applied in obtaining the two types of resources for use in the production system.

The second assumption is that resource sets which consist of some combination of instances of both resource subclasses are used to provide capacity to virtual community to complete business tasks or solve complex business problems.

The second assumption is based on a theoretical foundation that can be traced since 1984, when Wernerfelt proposed a simple tool [25] for strategic planning based on the proposition [26] that a company is not only a good production mechanism but also a resource processing mechanism. Barney [27], [28] suggested that resources are heterogeneous—not all organizations have equal access to them and effective use of resources is a key competitive advantage. Peteraf [29] argued that heterogeneity of resources is a source of economic rents (including monopoly rents). Grant [30] aggregated the research effort in his Resource-Based Theory of Competitive Advantage (RBCA); the concept of "resource team" is used to describe any set of inputs in the production process that provides the organization with "capability"—the capacity of the organization to complete certain business task or activity. Resources are a source of capabilities, which are a source of competitive advantage. So effective resource management is crucial for obtaining competitive advantages.

The first and the second assumption are used in a conceptual model[1] of the virtual community as a resource processing mechanism (Fig. 1.) The virtual community is presented by the *Community* class, which aggregates instances of the *CommunityMember* class and exploits a certain set of information technology *itsolution[1... *]*. Two subclasses of *Resource* represent the resources delivered respectively by community members *CommunityResource* and by the management team *OutsideResource*. The *ResourceTeam* class aggregates some combination of *CommunityResource* and *OutsideResource* in order to provide one or more *Capability*.

The frame in Fig. 1 represents the RBCA concepts applied to the virtual community domain. It provides a solid ground for business system modeling and virtual community strategic planning. Within RBCA a critical decision of the team that governs the organization is to create a system of mechanisms for resource provisioning and processing, thus providing capabilities. Within the pro-

[1]The conceptual models proposed in the article are presented with Unified Modeling Language (UML) 2.0 class and interaction diagrams.

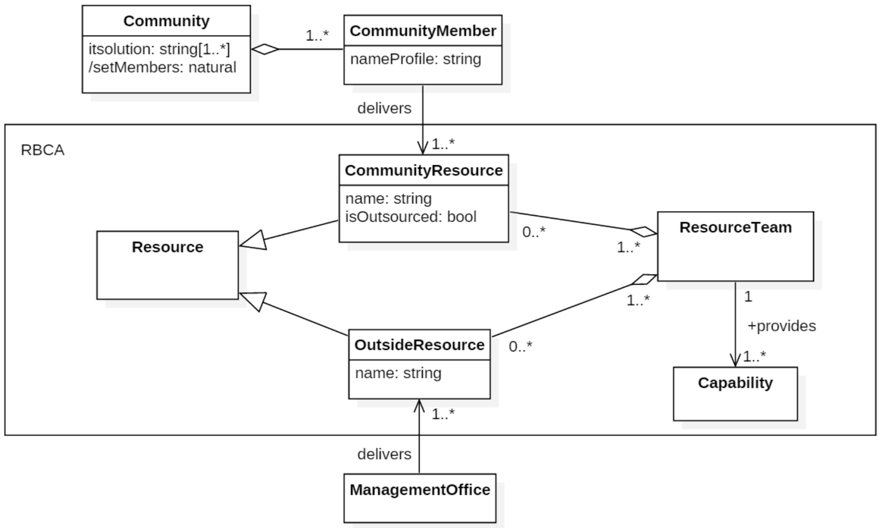

Fig. 1. Resource based view on virtual community

posed model the first type of resources are delivered and managed by the community governors; these may be donations, budgeted subsidies, marketing provided by partnering organizations or other products. The community resources are owned by community members and have unique extraction and delivery characteristics such that the quality and quantity of these resources which are an input in the community production system depend of motivation factors (some of them are explained in the Introduction section of this paper). The governing team is not able to manage directly the input of community resources; instead they have to create an environment that will stimulate that input and to implement a mechanism that will allow its effective use along with the resources that are under the governing team's direct management.

The third assumption is that the creative potential of the community can be used in complex undertakings if they are provided with a flexible management framework that would allow them to retain control over the endeavor and will provide feedback to the community governing team.

Such a management framework would allow community members to specify, undertake and manage their endeavors in a safe environment in which they can control parameters, resource inputs and outputs of the undertaking independently of the main community activities. The management effort can be safely delegated to the community members and the general community governing team may retain some control functions. In case of failure of the undertaking, its isolation will minimize the negative effects over the community; in case of success the benefits will be either directly or indirectly consumed by the community.

The fourth assumption is that in order to put the resources they own to effective use, virtual community members have to be provided with a mechanism that will support them with some services they may lack but need to put in their endeavors in order to achieve high quality or even to be successful.

The fourth assumption's reasoning is based on empirical evidence and observation of some of the most successful projects developed under the open source paradigm. Foundations and non-profit organizations like The Linux Foundation, Document Foundation, Open Source Initiative and Apache Software Foundation provide support to selected software development undertakings. However, these organizations are an outside source of raw resources or services to the project teams. The project teams retain control and ownership of the project, additional benefits for the outside organizations are negotiated (i. e., logo placement). The Linux Foundation [31] provides a pool of 12 predefined project services such as creative, PR, financial, IPR management, HR management which are available to supported projects. Some recent examples of successful products of this model are Node.js, Dronecode, Xen Project, among many others.

A resource processing system composed of two complimentary mechanisms that implement the third and the fourth assumptions is presented in Fig. 2.

Both mechanisms use resource teams of class *ResourceTeam* to produce goods of *Benefit* class. *Service's* outputs are provided either as direct benefits to the *Community* or as input to *Project*. The *Project* mechanism may employ specified *ResourceTeam* along with output of *Service* in order to process them in a discrete managed environment and produce goods.

Service class encapsulates a mechanism that uses standardized and repeatable processes to produce and deliver goods that provide benefits to the community. These goods may include basic items like discussion forums, file storage and transfer service or image hosting. Since they are a standardized and accepted way to provide a specific good it is easier to automate them and provide the needed software functionality. Services employ resource teams that may include both types of resource (i. e., a discussion moderation service may be provided with active and formal participation by virtual community members).

Each instance of *Project* encapsulates processes that may be unique to the system. The *Project* mechanism is meant to be used for producing goods that cannot be produced efficiently or at all using the processes and techniques standard for the system. Its isolation from the mechanism that produces standardized

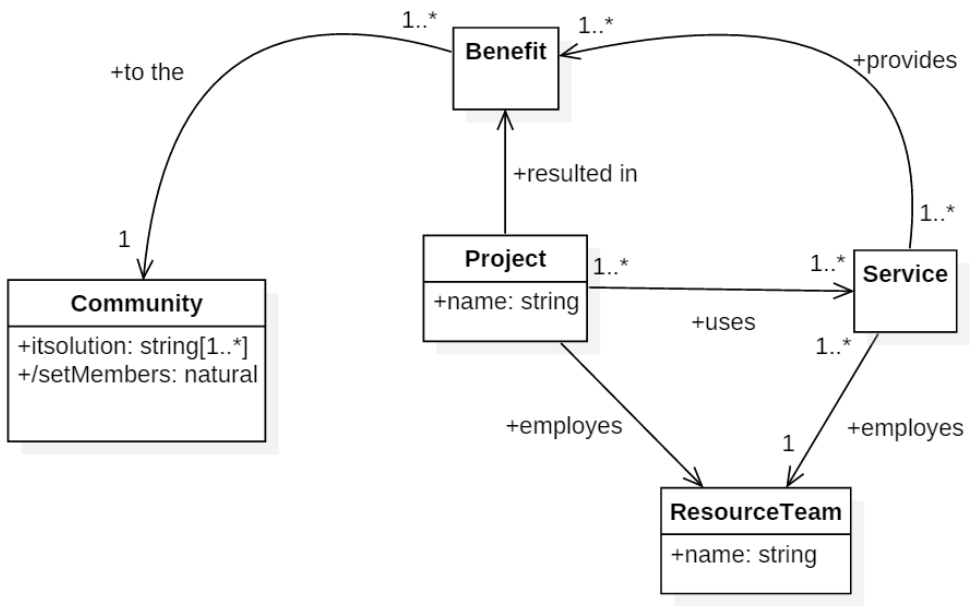

Fig. 2. Resource processing system

goods for the community guarantees that the failure of *Project* will be local and will not fail the normal functioning of the community system.

The community-sourcing approach provides a basis for studies of various aspects of virtual communities by software engineers, economists and sociologists. One of the possible applications is as a foundation for software design. Another application is in development of business model for virtual communities.

4. Conceptual model of a virtual community resource management system. The conceptual model presented in this section proposes a resource management system that implements the described community-sourcing approach. The purpose of the model is to further illustrate the concepts and the four assumptions of the approach and to present a framework that can instantly be used in practice.

The blending of two resource types and two resource processing mechanisms requires design of additional components and a coupling management subsystem to ensure synchronous work. One such design is presented in Fig. 3. The design implements the concepts described in the Third and Fourth assumption. It uses mechanisms that are based on industrial good practices and *de facto* standards in resource management—concepts of PMI Project Management Body of Knowledge (PMBOK) are used in the development of the project management mechanism and concepts of the AXELOS Information Technology Infrastructure Library (ITIL) v.3 are used in the design of the service management mechanism. The management office is the core unit that provides centralized management functions to the system and synchronizes the work of the mechanisms.

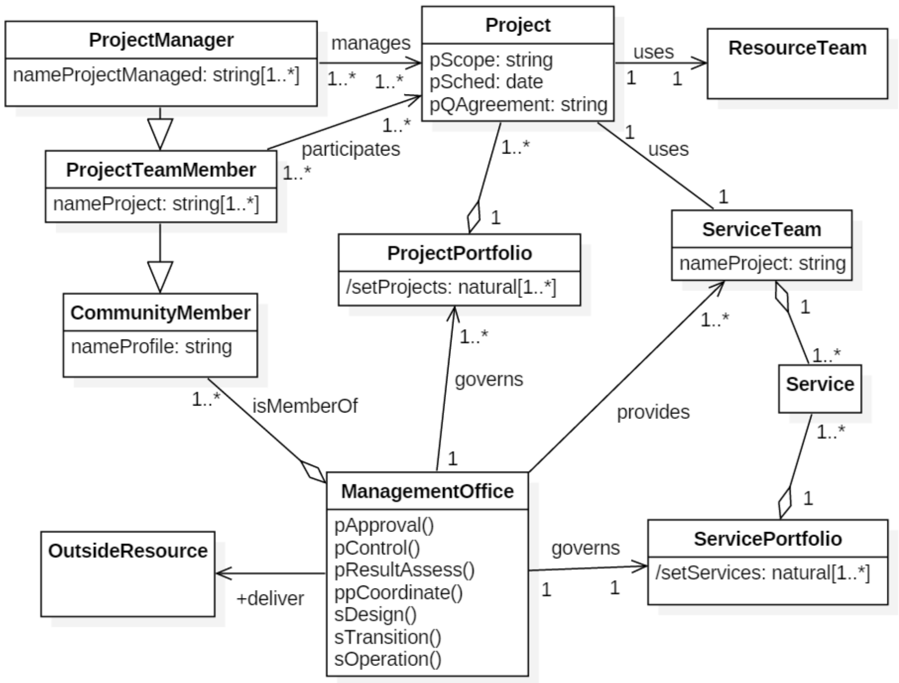

Fig. 3. Management office and management subsystem

The concept of service adopted by the system is defined in ITIL v.3: “A service is a means of delivering value to customers by facilitating outcomes customers want to achieve without the ownership of specific costs and risks.” [32]. It is represented by the *Service* class in the model. Service composition is not presented since it is provided by the current ITIL version and may change. *ServicePortfolio* class aggregates the instances of *Service* that exist in the system.

The concept of project adopted by the system is defined in PMI PMBOK [33]: “A project is a temporary endeavor undertaken to create a unique product, service, or result.” It is represented by the *Project* class in the model. Three attributes are used to store project scope (*pScope*), project schedule (*pSched*), project costs (*pCosts*), thus representing traditional Iron Triangle project constraints [34], and project quality specification (*pQAgreement*). The *ProjectPortfolio* class aggregates the instances of *Project* that exist in the system.

The *ManagementOffice* class contains methods for government of *ServicePortfolio* and *ProjectPortfolio*. However, different management approaches are implemented with the design of the methods.

The management office governs the service portfolio with methods that represent three of the service lifecycle phases in ITIL; they give the office both ability to directly and completely manage the instances of the *Service* class and to govern the *ServicePortfolio* with *spCoordinate()* method; additional methods may be added if needed; also more sophisticated relations may be described using the association class for *govern* association. There is no other authority that manages the instances of *Service* in the system, setting one point that owns the risks and provides benefits to the customers as per the presented definition of *Service*.

The management office governs *ProjectPortfolio* with the *ppCoordinate()* method; additional methods may be added if needed; also an association class may replace the *govern* association if more sophisticated relations have to be modeled. The core difference between service and project management is that the management office does not directly manage various projects that comprise the project portfolio. The management office approves the project parameters (as described by attributes of *Project* class), receives and assesses feedback information and assesses the results of the project which may or may not include implementation of the results in the community. The project team *pTeam* performs the project management activities. The management office provides coordination (exchange of information, know-how, results, etc.) between projects and since it is the authority that manages the services in the system it allows effective service capacity management. The *ServiceTeam* class represents the set of services that may be assigned by the management office to a particular project.

The entire system is managed by the community. The key idea is that in all types of virtual communities, even in the most commercialized branding communities, the governing team members are inevitably also community members since they own user accounts in the community and try to participate and influence its life. The *CommunityMember* class models a member of the community; instances of this class are associated as members of the management office. Team members of particular projects are instances of the class *ProjectTeamMember*, project managers are instances of the class *ProjectManager;* both classes are generalizations of the *CommunityMember* class.

The presented model provides community with an environment in which any member can start or participate in some endeavor under the project concept. The endeavor is isolated and safe (as per the Third assumption) and can be supplied with some needed services (as per the Fourth assumption). Each project may safely create and manage discrete resource teams (most certainly comprised by set of community resources); service needs may be evaluated, negotiated, provided used and released within a cooperative negotiation procedure. An example of such a procedure is described in Fig. 4.

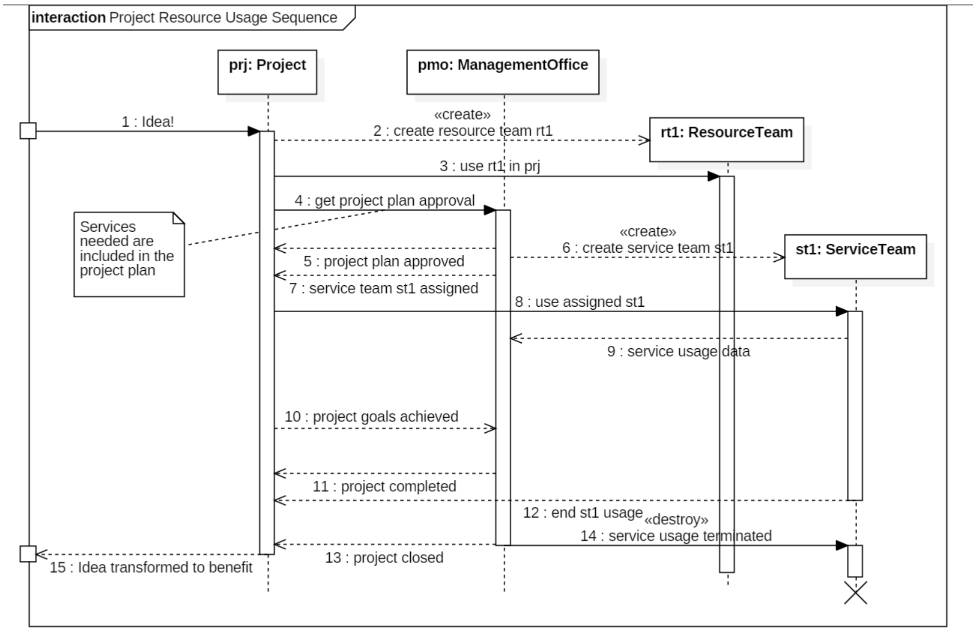

Fig. 4. Project–management office interaction

Some idea is born in the community, a project team is formed and the project instance (prj:Project) is created. An instance rt1:ResourceTeam is created since it is managed solely by the project team. A project plan along with needed services are presented to the management office; the project is eventually approved and an instance st1:ServiceTeam is created and assigned to prj:Project. When project goals are achieved (or the project is closed and marked as completed by pmo:ManagementOffice by some other reason) service use is terminated and the service team st1:ServiceTeam is destroyed. Note that service usage data messages are gathered by the management office—since its authority is a continuous optimization of services this may present valuable information. Also notice that rt1:ResourceTeam may not be destroyed after the project ends—it may safely exist outside the project frame, which in this case is intended to present a controlled environment for provisioning with services that are under the authority of the management office.

A system that is a fusion of all four assumptions of the community sourcing approach and the concepts described in this section is presented in Fig. 5. It provides a framework for holistic management of the systems' resources existing in the virtual community. The management office is responsible for delivery of outside resources; instances with varying composition of *ResourceTeam* are used by projects and services in order to provide benefits to the community.

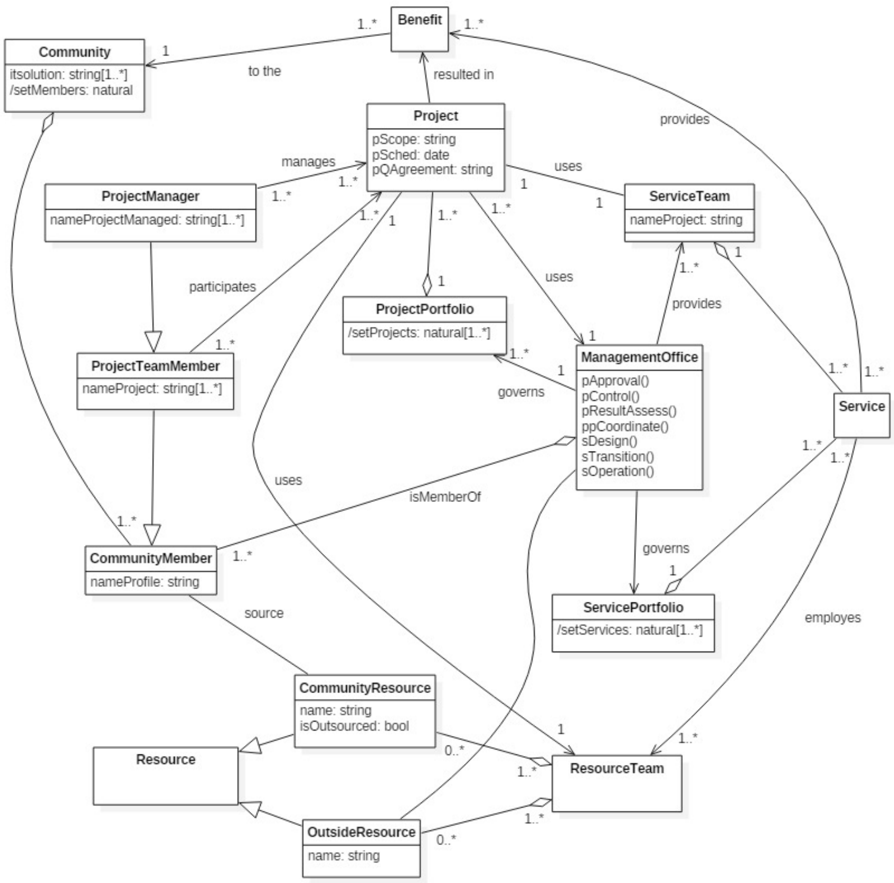

Fig. 5. Virtual community resource management system

The classes and associations representing concepts of good practices may be remodeled and improved with the evolution of these practices; also methods and attributes may be overwritten if specifics of the business case require that. The proposed conceptual model presents a complete system that may be applied as a management model in existing communities with already developed software platforms or in planning phases of development of communities or new software products for virtual communities.

5. Model validation. The validation of the model and the assumptions of community-sourcing approach require rigorous testing in practice. Although some of the presented concepts extract viability from frameworks and business models that are already good and proven practices, the core of the community-sourcing is its systematic approach, thus it cannot pretend for viability merely by citing viability of its parts. The results presented in this section are achieved within implementation of the model in a virtual community with about 10,000 participants. Data is gathered in a period of 13 months before and 12 months after implementation of the model (over 900,000 samples of visitor data are gathered by web analytics software). The results present two clues for the practical viability and potential economic benefits of the model and community-sourcing approach; these clues are not ultimate, however they present ground solid enough for further investigation.

Since we study virtual community as a production system we can use a Neoclassical production function [35] that describes the goods produced in an economic system:

$$Y = A(t)F(K, L) \tag{1}$$

Y — the produced output,
K — capital,
L — labor,
$A(t)$ — the technology factor.

In Leimester's definition of virtual community both adopted organization model and technical platform represent $A(t)$—a technology factor external to the production system. Since $F(K, L)$ is always positive, the implementation of a better organization model will increase the value of $A(t)$ and will increase the system output Y.

However, specification of Y presents a research problem. We can further review two perspectives to the virtual community:

- Social perspective—virtual community as a social organization.
- Economy perspective—virtual community as a resource processing and goods production mechanism.

RBCA suggests that better resource management would provide competitive advantages; under a social perspective that could mean a community that provide better member experience, under an economy perspective that could mean more direct profit; or both effects may appear. Currently there is no particular metric that may describe the produced output. Thus several other *de facto* standard metrics are analyzed and techniques of comparative analysis are used in the validation effort presented in this section. Also some derivative metrics that include costs as a parameter are produced in an attempt to provide clues for economic viability and increase in effectiveness.

The first validation clue is based on data development of some *de facto* standard metrics for one activity before and after implementation of the management system based on the presented conceptual model. The activity is a competition that is held semiannually online on a web platform that provides infrastructure to the virtual community; it has homogenous structure (rules, technical requirements, competition software) over the entire observed period. Each edition of the competition generates peaks in interest in the community for a period of about 10 days before and after the date of the actual event. Four editions are studied. The first two editions are held in a management environment that only provides budget to a team of experts that prepare the competition components and are responsible for marketing activities and public communication regarding the event. The last two editions are held in a management environment that completely implements the presented conceptual model; the competition project team is provided with a budget (outside resource) for content development and with two predefined services—administrative and marketing. In all four editions the team own the content development, however in the last two editions administration and communication with the participants and all public communication is provided to the team as a service by the management office.

Table 1 provides data for three metrics—visits, page views and participants per edition. Data are gathered for a period of 10 days before and 10 days after each edition.

Costs per edition BR_n (2) are presented in units relative to first edition.[2]

[2]Some of the costs are financed as part of agreement with a commercial organization and actual currency values fall under a confidentiality clause, thus relative units are calculated instead.

Table 1. Data for four editions of the initiative

	1 ed.	**2 ed.**	**3 ed.**	**4 ed.**
Visits	9280	3867	13879	7574
Page views	57461	20637	96107	45587
Participants	675	288	1135	491
Costs in relative budget units BR_n	100	90	90	67
Budget units per participant $BUPpant_n$	0.15	0.31	0.08	0.14
Budget units per page view $BUPgview_n$	0.00174	0.00436	0.00094	0.00147
Budget units per visit $BUVisit_n$	0.0108	0.0233	0.0065	0.0088
Change $Pgview_n$ **rel. first edition**	0%	111%	−46%	−8%
Change $Pgview_n$ **rel. first edition**	0%	151%	−46%	−16%
Change $Visit_n$ **rel. first edition**	0%	116%	−40%	−18%

Costs include the invested budget for the first two editions and budget and costs of services for the third and fourth edition.

$$BR_n = \frac{BV_n}{BV_1} 100 \tag{2}$$

BR_n — costs of edition n in relative units,
BV_n — costs of edition n in BGN.

To study the effectiveness of the resources used represented by calculated costs per edition, the derivative metrics $BUPpant_n$ (3), $BUPgview_n$ (4), $BUVisit_n$ (5) are used.

$$BUPpant_n = \frac{BR_n}{PCnt_n} \tag{3}$$

BR_n — costs of edition n in relative units,
$PCnt_n$ — number of participants in edition n.

$$BUPgview_n = \frac{BR_n}{Pgview_n} \tag{4}$$

BR_n — costs of edition n in relative units,
$Pgview_n$ — number of page views in edition n.

$$BUVisit_n = \frac{BR_n}{Visit_n} \tag{5}$$

BR_n — costs of edition n in relative units,
$Visit_n$ — number of visits in platform during edition n.

The influence of the season factor has to be counted in data analysis—the second and fourth edition are held in late spring when the potential audience (school students) is much less than in the winter when the first and third edition were held. A direct comparison of the data for the first and third edition presents 40–46% less invested resources per metrics results; the difference is 120–170% when the second and fourth edition are compared. The preliminary results of the fifth edition that was held in December 2016 present even better results—with costs of 67 units 1302 participants were registered or $BUPpant_5 = 0.05$. In the analysis of the factor influence one has to notice that although the registered users in the community are rising with about 3000 in 2014 and 2015, active users per year are almost constant—around 4000; also the total number of visits per year is rising steadily with around 7% each year; another suggestion is that the project team is getting better and the initiative is becoming a tradition which also influences the results; however, the change in numbers is sharp and the positive feedback from the audience and the project team that may not be expressed with numbers leads to the assumption that the change of the management model is the main factor for the improvement.

The second clue is based on a comparative analysis of the values of a derivative metric $BUPgviewTW^t_n$ (7) which is used to compare cost effectiveness for 5 initiatives that are developed as projects in the same virtual community after the implementation of the presented management model. This metric is used since the initiatives have heterogeneous output which made impossible direct measurement and comparison of the output values (i. e., one of the initiatives produces video content, another is an online competition, yet another is an online course for an audience of school teachers, etc.). The variations presented by the information architecture of the sections of the initiatives are reflected with inclusion in (7) of the average time spent by a visitor in the initiative's section pages; the variations of content quality cannot be represented, since it is not possible at the moment to calculate the average time spent by the visitor in the initiative's section and related content per visit, which would be a better metric.

The costs (6) of any initiative $BInitiative_n$ are presented in relative units to the costs of a base initiative $BCurrencyInitiativeBase^t_n$ (the base initiative is initiative four, which is the competition described in the last section):

$$BInitiative_n^t = \frac{BCurrencyInitiative_n^t}{BCurrencyInitiative_{base}^t} 100 \quad (6)$$

$BInitiative_n^t$ — costs of initiative n for period t in relative units,
$BCurrencyInitiative_n^t$ — costs in currency (BGN) of initiative n for the time period t,
$BCurrencyInitiative_{base}^t$ — costs in currency (BGN) of the base initiative for the time period t.

The derivative metrics named "Time weighted cost of page view" is calculated per initiative:

$$BUPgviewTW_n^t = \frac{BInitiative_n^t}{Pgview_n.TVisitAVG_n} \quad (7)$$

$BInitiative_n^t$ — costs of initiative n for period t in relative units (6),
$Pgview_n$ — number of page views, registered in initiative n's site section for period t,
$TVisitAVG_n$ — average for period t time spent by visitor in initiative n's site section, in decimals.

The time period t spans 12 months in 2015–2016. In the calculation of the average time of the visit, bounces (visits of under 10 seconds, which are considered site navigation design faults) are eliminated. The values are presented in Table 2.

Table 2. Data for five initiatives in a 12 months' timeframe

	I1	**I2**	**I3**	**I4**	**I5**
Costs $BInitiative_n^t$	33	33	33	157	80
$TVisitAVG_n$	1.32	1.13	1.13	1.45	1.35
$Pgview_n$	19148	84246	35693	43716	22195
$BUPgviewTW_n^t$	0.0013	0.0003	0.0008	0.0025	0.0027

Initiatives 1, 2 and 3 are knowledge sharing online events and have a duration of 60–90 days; initiative 4 is an already presented competition which was held two times in the studied timeframe; initiative 5 is another online competition held monthly. I4 and I5 have been developed since before the implementation of the new management model, the other three initiatives were created as community projects after the implementation. The improvement in various metrics of I4 after the implementation of the new model was already studied and a relation was suggested. In direct comparison with other initiatives the cost effectiveness presented by $BUPgviewTW_n^t$ is better in I1, I2, I3 than in I4 and I5.

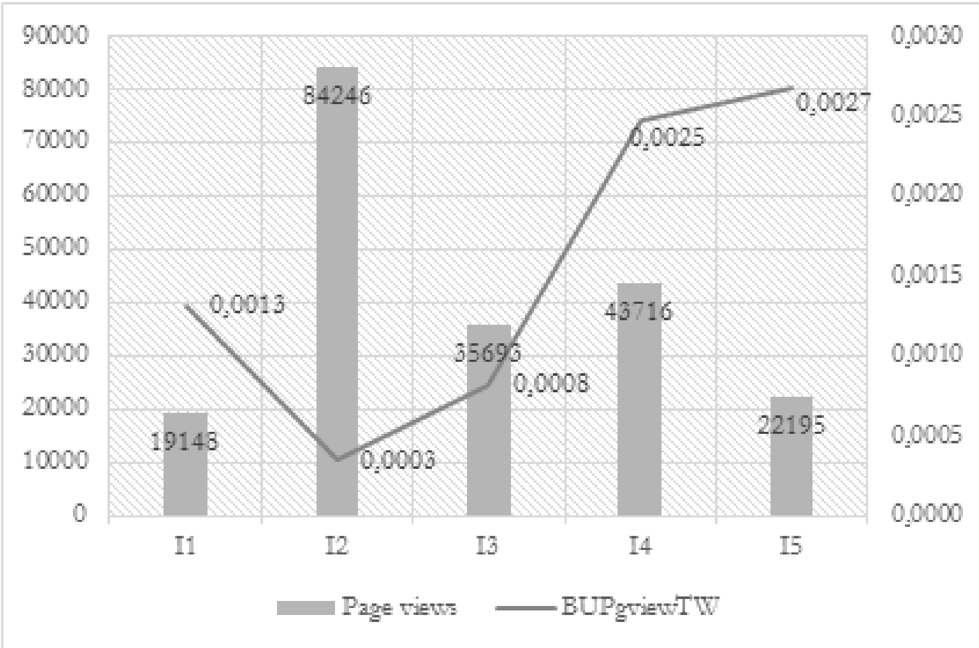

Fig. 6. Comparison of initiatives

I4 and I5 are perceived as successful initiatives by community leaders, corporate sponsors and experts; however, by studying the three initiatives that started development after adoption of the community-sourcing management model the cost per generated page view of I1, I2, I3 is significantly lower than the costs of I4 and I5 (which also lowered their costs after the adoption of the model). Also, note that I2 is generating about twice as many page views than the significantly costlier I4. It would be speculative to claim that any of the initiatives is generally better than others based on this derivative metric that measures engagement of the visitors compared to costs, however the results give a clue for economic viability. The clue is strengthened by the fact that all of the initiatives I1–I3 produce goods of considerable quality compared with similar activities (i. e., video content that generates tens of thousands views; thousands of interactive web accessible teaching materials produced by school teachers; 20 unique math miniatures—video content and interactive JavaScript applets, etc.)

The presented results give preliminary clues for the economic and practical viability of the presented management model based on the community-sourcing approach. Further study of virtual communities that apply the model may present additional pro or contra clues about its viability. Further study of virtual communities that apply the four principal assumptions of the approach may provide data for improvement of the management model or development of an entirely new model.

6. Conclusion and research agenda. The community-sourcing approach for resource management in virtual societies presented in this paper is based on studies of an open source business and product development model and a crowdsourcing approach and their numerous implementations. Community-sourcing implies development of a virtual community that provides managed environment for production of goods by teams of community members that use both own resources and services provided by the community government. The presented research is interdisciplinary and provides a foundation for further research on a wide range of topics. It may be of interest for researchers in economics, management science, sociology and computer science. A sample research agenda with four major topics is presented:

- Further studies of the open source model and crowdsourcing model and comparative analysis with the proposed community-sourcing approach. Particular studies of the liberal nature of open source model compared to more restrictive crowdsourcing and community-sourcing as a middle ground are needed.
- Study of the possible change of participation and engagement in the virtual community with implementation of the community-sourcing environment. The suggestion is that the approach may create a loop—the concept of project is used to facilitate already studied motivational factors; however, participation in projects eventually may further boost general participation and engagement of community members.
- Applications of community-sourcing as a universal production framework. Detailed management models that implement the community-sourcing approach for particular application domains may be developed that complement or entirely substitute the conceptual model proposed in this paper.
- Metrics and a methodical framework that will allow better study of the economic effectiveness of the virtual community as a production mechanism. Description of more advanced techniques for statistical analysis that may be applied.

With research development of the presented sample agenda and further implementation of the approach in practice the validation effort is projected to present more results with better quality.

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